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Original Article

# Interaction and Navigation in Immersive Virtual Heritage Environments for the First and Third Person Perspective

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**Abstract**: Immersive capabilities in virtual applications have been attracting huge interest from researchers and developers. In this paper, we discuss interaction and navigation, which are the key elements creating a sense of immersion, for first and third-person perspectives in immersive virtual heritage applications. We design and develop an immersive virtual application for user experience from which we take and analyze user feedback on the mentioned interaction and navigation aspects. The results indicate that in some purposes and interactive applications, the first-person perspective is the appropriate choice and vice versa, with spatially wide applications, the third-person perspective is better.

*Keywords*: Immersive applications, Virtual heritage applications, Interaction, Navigation

## 1. Introduction

Heritage is representative stowage for our memories and provides us with a physical means to connect to past values. By the time, any physical material will inevitably drop in quality. So, digital preservation of heritage is one of the significantly important solutions. As digital copies can preserve and generate more valuethan their physical part in the long term, virtual records will be both necessary and useful for future research. Virtual heritage helps audiences experience anytime, anywhere, and especially is a safe archive from disasters [1]. Virtual heritage helps audiences access and learn about precious artifacts and materials. Many researchers and heritage practitioners have studied to implement virtual heritage in their objective of heritage protection and research. Virtual reality and augmented reality (VR/AR) technologies have the ability to simulate a complete and interactive virtual environment for the audiences to get a more comprehensive and concrete understanding of life in the past. More importantly, virtual heritage enables the audiences full access to the heritage with no restriction on physical location and time.

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In a virtual heritage application, HCI (Human Computer Interaction) researchers often analyze aspects of usefulness, usability, and user experience. When analyzing user experience, the following aspects need to be taken into account: aesthetic qualities, expression of motor, and psychological reactions that are influenced by the interaction methods and navigation in the virtual environment. So, with the development of VR/AR technology, different interaction methods and how to navigate naturally and efficiently in the virtual environment have become a hot topic of research.

In this paper, our aim is to investigate the efficiency of interaction and navigation in an immersive virtual heritage environment when users take on the roles of first-person and third-person perspectives. With applications where performance and development time are prioritized, developers often choose only one of the two perspectives. The aim suggests an appropriate perspective for development. Additionally, there are applications that can incorporate both perspectives seamlessly. The aim suggests switching to the appropriate perspective for each context to enhance the user experience. To do that, we design a test environment in the form of an immersive virtual musical heritage application. Then, we write a test scenario, let the user experience our application, get feedback from them, and analyze the feedback after they experience the immersive environment. Our contributions are as follows:

To design and build an immersive virtual heritage musical demo application for first-person and third-person perspectives.

To implement test scenario, and to collect feedback from users after they experience the demo application.

To give comments on the efficiency of interaction and navigation for first and third-person perspectives from users' feedback.

The rest of the paper is organized as follows: Firstly, we give an overview of the first andthird-person perspectives in immersive virtual applications and related works in section 2. Section 3 presents the whole process of our test. The basis for building the application and how to evaluate the results are outlined in section 4. The process of building an immersive virtual musical heritage application is depicted in section. 5. In section 6, we describe the experience and feedback from the user. Results are analyzed and implications are discussed in section 6. Finally, section 7 concludes the study.

## 2. Background and related works

### *2.1. Background*

**Interaction** in an application evolved from CBL (command-based line), GUI (Graphic User Interface), WIMP (window icon menu and pointer) to NUI (Natural User Interface). A system with NUI allows user operates through intuitive actions related to natural, everyday human behavior. An immersive application is a system using NUI, so the design of interaction is the most important issue to help users have the most natural experience.

In a virtual immersive application, **first-person perspective** is that the user observes the environment through the eyes of a character while a **third-person perspective** places the user's perspective behind or around the character.

In the world, VR technology has been applied in many different fields and is expected to become a new trend. The industry's revenue in the global market is expected to reach 48.5 billion USD by 2025. VR is the use of 3D scanning and 3D reconstruction technology to reproduce space in a realistic, vivid way based on digitizeddata. With the help of VR headsets, users with an internet connection can see, explore, and even interact almost realistically with landscapes anywhere. Especially, some VR systems not only display environment as a mere 3D image, but also simulate sounds, and even smells quite realistically. For the heritage sector, the application of VR technology in the reenactment and restoration of monuments and landscapes are not new so far. It can be seen that the reproduction or restoration of monuments and heritages by

technology in general and VR technology, in particular, are very practical because it has both scientific significance and cultural value, helping the heritage to last forever. Users experience heritage applications eager to discover more information about civilizations around the world. It is the responsibility of heritage applications to convey messages about the history, culture art, etc. of the civilizations. As for VR technology, based on the collected data, the architectures will in turn be restored with specialized software to be closest to the original, from scale to architectural style. Therefore, people who experience heritage in this way can not only see the heritage in an authentic way but also "live" in the heritage through real interactions.

### *2.2. Related works*

Recently, Geoffrey Gorisse et. al. [2] compared the impact and the potentialities enabled via the integration of the third-person perspective in immersive virtual environments. Authors in [3] proposed the multi-perspectives interface which integrates the first-person and the third-person perspective in VR industry application. In [4], authors investigated whether playing in the first-person perspective is more immersive than the third-person perspective in digital games. They illustrated that the first person sometimes limits the users' ability to see their situation within the game, and so causes a greater sense of challenge when playing. However, it may be that users prefer the first-person perspective, because of the greater challenge it presents in the virtual world of the game. In [3], a multi-perspective interface (MPI) integrating first and third-person perspective was presented for narrow assembly spaces in industrial design. Authors showed that the MPI allows users to improve their interaction performance and assessment ability in narrow assembly spaces. In [5], authors presented the impact and the potentialities enabled via the integration of the third-person perspectivein immersive virtual environments to assess the sense of presence, the sense of embodiment, and the performance of users. There are no significant differences concerning the sense of spatial presence. Both first- and third-person perspectives seem consistent with the induction of a high spatial presence feeling. However, the authors showed that the first-person perspective induce a sense of embodiment better and enable easier interactions.

The mentioned studies have made comments about the convenience of different perspectives of users when interacting. However, virtual heritage applications have unique and diverse interactive objects that have not been comprehensively and deeply pointed out. Therefore, in this paper, our aim is to test and evaluate the interaction and navigation experience with first-person and third-person perspectives in virtual heritage application.

## 3. Method

Different phases of immersive virtual environment-based experimental studies were presented and discussed by Heydarian and Becerik-Gerber [6] for researchers and virtual application developers when they build experimental studies. Bayed on the phases, we proposed a process of 4 phases including the definition, development, implementation, and analysis phases (Figure 1) in creating and analyzing experiment test scenario of different interaction method effects and navigation when users role-play in first-person and third-person perspectives. We tried to discover the difference and effectiveness of the methods of interaction and navigation when users role-play in 2 different roles.

The definition phase outlines the test purpose, plans the test development timeline, plans the test environment development, and chooses a method of test evaluation. In the development phase, a case study of building an immersive virtual heritage is deployed. We write test scenario, create evaluations, deploy the test following the test scenario, and collect feedback from users in the implementation phase. Finally, we analyze the feedback result and give some implications.

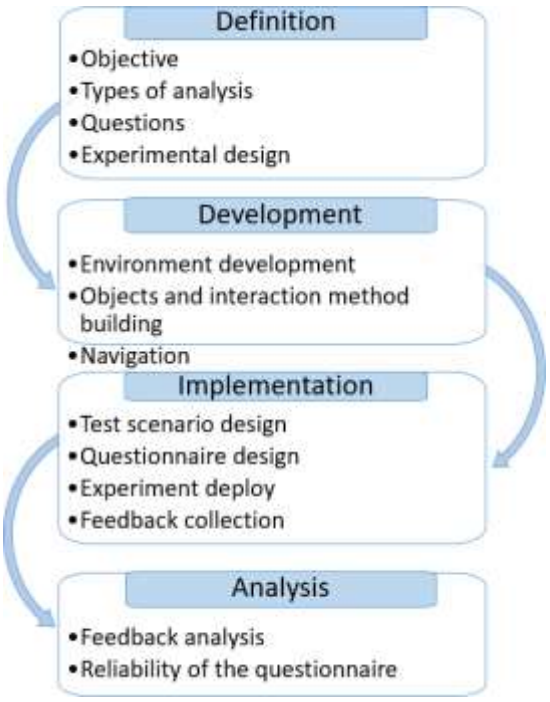


Figure 1. Phases of our proposal.

Table 1. Different methods of interaction

| No | Data type | Interactions |
|---|---|---|
| 1 | Text | on/off, scroll, Zoom in/out |
| 2 | Audio | on/off, volume up/down |
| 3 | Image | on/off, present on/of |
| 4 | Video | on/off, volume up/down, Backward/forward |
| 5 | 3D model | rotate, pick, hold |

## 4. Definition phase

VR/AR has been proven as a promising tool for virtual design and has brought a new and attractive experience to users in the form of immersion. In order for immersive applications to bring effective results, interactions within the application which depend on user roles need to be carefully designed. Recent studies as mentioned in section 2 have discussed some aspects of different users' perspectives when interacting in the immersive virtual application. However, virtual heritage applications have unique and diverse interactive objects that have not been clearly and deeply pointed out. Therefore, our objective is to analyze and evaluate the interaction experience and navigation in virtual heritage applications in the form of first-person and third-person perspectives.

To archive this objective, we conduct a user survey about the effectiveness of interaction and navigation in an immersive virtual heritage application. First of all, we build an environment of immersive virtual heritage. Then, we let the users experiment with the interaction and navigation in the environment and collect feedback from them. Based on the analysis of the feedback from users, we will recommend suitable role-playing roles in different immersive virtual heritage applications.

The peculiarity of virtual heritage applications is to provide information and expect users who use the application to remember the provided information. Moreover, virtual heritage applications include a lot of documents and artifacts in different formats called multimedia data. From a technology perspective, the data types can be text, audio, image, video, and 3D model. Each type of data will have its own approach and interaction. For artifacts in 3D model format, for example, the users want to touch and hold them to find out their shape, size, mass, material, etc... When representing these types of data in a virtual heritage application, the associated interactions are listed in Table 1. Another important and indispensable element in the virtual application is navigation. The process of navigation within an environment is often called wayfinding including looking for the direction and arriving at a destination through an environment. In this project, we also evaluate the convenience of users when they navigate in a virtual environment in different roles. We design and build a fully compact immersive virtual heritage including different types of data and types of navigation. In the application, we develop role-switching functions between the first and third-person perspectives. Next, we let the users experiment with the application and then collect and analyze their feedback.

There are different methods for the assessment of a virtual heritage application, such as informal expert review; usability evaluation of prototypes or final product testing by the user; survey with written questions prepared by the designer and answered by users; user interview by discussion between designer and users; discussion in focus group including a wide range of stakeholders, researchers, and users; or collecting information concerning the environment in which the artifact will be used. Various assessments all aim to evaluate the satisfaction with which the interactions can be achieved with specified goals in virtual heritage environments. With immersive applications, user feedback is the most important. Therein, the creation of likert-type questionnaires is a reasonable choice for two reasons. Firstly, the selection of a question is both quick and easy for users. Secondly, designers can create groups of questions with different purposes. There are some standardized likert questionnaires such as SUS [7], UMUX [8], UMUX LITE [9], SUMI [10], USE [11] and QUIS [12]. For each newly defined questionnaire, it is necessary to evaluate the effectiveness of the questionnaire. With the above advantages, we designed a likert-type questionnaire consisting of 5 questions (Table 2) categorized into 2 groups. The first group includes 3 questions about the effectiveness of interaction, the other group includes 2 questions about the effectiveness of navigation when the user switches between first and third-person perspectives.

Table 2. Our questionnaire

| No | Questions |
|---|---|
| 1 | Do you hold the object correctly? |
| 2 | Do you interact with video/audio/image eaily? |
| 3 | Do you interact with text easily? |
| 4 | Do you determine the direction easily when navigating? |
| 5 | Do you feel and observe the space well? |

## 5. Case study: Immersive virtual musical museum application

We chose to build a compact immersive virtual heritage application in the form of a virtual musical museum (called MusicVRapp) introducing musical instruments. With the goal of interaction in the application, we only build a compact museum environment and at least 1 data and its interaction for each data type. The process of the application building is shown in Figure 2.

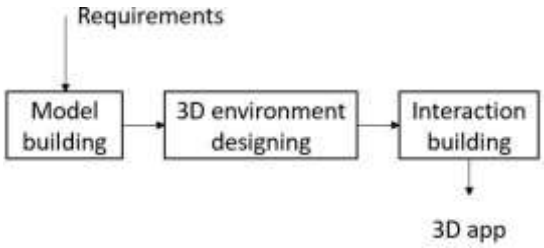


Figure 2. Process of the immersive virtual musical application building.

Firstly, we build 3D models of pianos, guitars, t'rungs, drums, and flutes (Figure 3). In addition, we collect some music audio, pictures, texts, and videos introducing famous composers, musicians, and music bands (Figure 4). Then, we build an 3D environment (Figure 5).

With the character that the user roleplays, we develop character movement and interaction functions for different data types. The characters move through keyboard controls or the VR headset's controller. Collisions are handled when the character moves in the environment. The character can rotate, pick up and hold the 3D model data through the keys on the keyboard or controller. For audio and video data, we develop on/off, volume up/down and forward/backward functions. Text data can be opened/closed and scrolled to a new page. In addition to open/close functions, image data can be clicked to link to text data. In order for the user to role-play in the first-person perspective, we set up the camera at the character's eye position that is moved following the character's movement. When the user switches to the third-person perspective, the camera will be set at the offset 0.5m above and 2.0m behind the character.

Figure 3. Some 3D models.

Figure 4. Some image, video, and text data.

Figure 5. 3D environment.

## 6. Evaluations

After completing the MusicVRapp, we proceed to collect user feedback in the following scenario:

- To introduce testing purposes: evaluating the effectiveness of interactions and navigation in immersive virtual heritage applications when users immerse themselves in first- and third-person perspectives

- To guide how to experience the demo application: How to control the keys on the keyboard and to control the button on the controller.

- To let users experiment with the demo application.

- To collect user feedback through the questionnaire.

A group of 37 subjects (16 females and 21 males) between the age of 18-32 participated in the experiment. All subjects completed the evaluation in a timely manner. The evaluation methods included an electronic version. Each subject received a questionnaire with 5 questions related to the tasks (experience with first and third-person perspectives). The subject answered questions by selecting one of 5 points (from 0 to 4) from strongly disagree to strongly agree.

Table 3. Mean scores of questions in the questionnaire

| Questions | 1st person | 3rd person |
|---|---|---|
| Q1 | 3.19 | 2.57 |
| Q2 | 3.46 | 2.92 |
| Q3 | 3.24 | 2.46 |
| Q4 | 2.68 | 3.38 |
| Q5 | 2.92 | 3.49 |

The results and findings were presented on the theme of issues, including interaction and navigation with first and third-person perspectives in MusicVRapp. Users get to experience the MusicVRapp following the test scenario including performing navigation and

interacting with different data types before answering survey questions. The results of the experiment are provided in Table 3 and Figure 6 The analysis of feedback indicates that on a 4-point scale, the average user rating is consistently higher than 2.57, with over half of the average ratings being above 3.0.

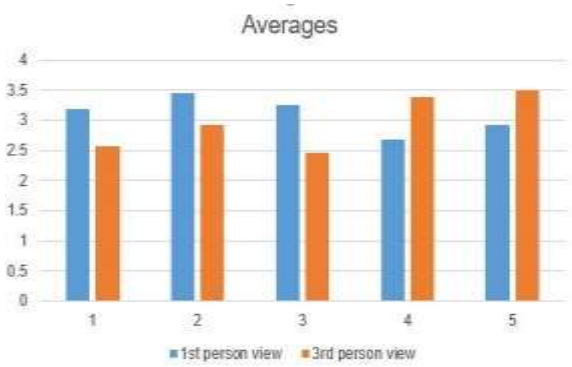


Figure 6. The average feedback from users.

Based on the responses to questions 1, 2, and 3, we know that users interact with the objects (in different data types) more conveniently in the first-person perspective than that in the third-person perspective. With the first-person perspective, the character's observation and the user's perspective are identical, so the userscan interact more accurately. This showsthat first person immersion is a good choice for interactive applications in general, which includes interactive virtual heritage applications.

The user with third-person perspective was standing behind the character to observe the environment. Third-person perspective allows the user to explore the position of the character in a specific context and to have a broader view of the context. This is illustrated by the answers to questions 4 and 5. Users have a better and wider spatial perception and perform better navigation. In case the application has a lot of artifacts and interactions first-person perspective should be chosen to implement. When the application has a large environment, the viewing experience is more than an interactive one, the third-person perspective is a better choice. We offer the ability to change between thefirst and third-person perspectives in a virtual heritage application in case the hardware platform meets the requirements. Playing in first-person perspective can provide for a more immersive experience when interacting, while third-person perspective helps the user perform more accurate character movements.

We estimated the Cronbachs Alpha coefficient of the questionnaires. The values of Cronbach's are 0.72 and 0.73 for data from first and third-person perspectives respectively indicating that the consensus of the subjects evaluating related questions used to evaluate the interaction and navigation in the MusicVRapp is accepted.

## 7. Conclusion

Our study allows the identification of the effectiveness of interaction and navigation by the use of both first- and third-person perspectives in immersive virtual heritage applications. Therefore, it contributes to the exploration and understanding of the effect of user roles in immersion.

Beyond the experience and feedback from the users, we were able to analyze different situations suitable for the use of each viewpoint. When in the third person perspective, the users are aware of space and the environment better so they navigate faster. However, the users interact with the artifacts and models more difficult. The analysis of the result in terms of the effectiveness of interaction and navigation demonstrates that for the applications with a lot of interaction, we should use first-person perspectives, and for those with a lot of movement and a high spatial presence feeling, we should use the third-person perspective. We hope that the identification of suitable situations concerning the studied viewpoints will support the development of potential new immersive virtual heritage applications more suitable.

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